DECLARATION

I,Noboru YOSHIDA, of SHIGA INTERNATIONAL PATENT OFFICE, 2-3-1, Yaesu, Chuo-ku, Tokyo, Japan, understand both English and Japanese, am the translator of the English document attached, and do hereby declare and state that the attached English document contains an accurate translation of the official certified copy of Japanese Patent Application No. 2000-182283 and that all statements made herein are true to the best of my knowledge.

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(Title of Invention)	FRICTION RESISTANCE SHIP AND METHOD FOR REDUCING FRICTIONAL RESISTANCE OF SHIP BODY
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[Document Type] SPECIFICATION

[Title of the Invention] FRICTION REDUCING SHIP, AND METHOD FOR REDUCING FRICTIONAL RESISTANCE OF SHIP BODY

[Claims]

[Claim 1] A friction reducing ship that reduces frictional resistance of a ship body by ejecting gas bubbles on a submerged surface of the ship body, comprising:

a negative pressure forming section protruding from the submerged surface of the ship body for creating a negative pressure region in the water having a pressure lower than a pressure in a gaseous space;

a discharge opening disposed at the rear of the negative pressure forming section for ejecting gas bubbles towards the negative pressure region in the water;

a fluid passage having one end open to the gaseous space and having the other end open in the water by way of the discharge opening so as to direct a gas from the gaseous space into the water; and

a gas supply apparatus for supplying the gas towards the negative pressure region.

[Claim 2] A method for reducing frictional resistance of a ship body by ejecting gas bubbles on a submerged surface of the ship body, comprising:

creating in the water a negative pressure region, having a pressure lower than a pressure in a gaseous space, resulting from the ship body cruising through the water, directing a gas from the gaseous space to the negative pressure region in the water so as to eject bubbles into the water, and supplying the gas to the negative pressure region by using a specific apparatus.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

This invention relates to a friction reducing ship in which frictional resistance of a ship body is reduced, and a method of reducing frictional resistance, and in particular, to improving the total energy efficiency by efficiently ejecting bubbles into the water.

[0002]

[Prior Art]

Conventionally, methods have been proposed for the purpose of reducing energy consumption when a vessel or the like is cruising, in which bubbles are ejected into the water and frictional resistance between a ship body and the water is reduced by interposing a multitude of bubbles in the vicinity of the surface (submerged surface) of the outer hull of the ship body.

[0003]

Techniques of generating bubbles in the water are proposed in Japanese Unexamined Patent Applications, First Publication Nos. Sho 50-83992, Sho 53-136289, Sho 60-139586, Sho 61-71290, and in Japanese Unexamined Utility Model Applications, First Publication Nos. Sho 61-39691 and Sho 61-128185.

[0004]

In these techniques, methods for generating bubbles in the water rely on equipment such as pumps and blowers to eject pressurized gas into the water through a plurality of holes or porous plates provided on the ship body.

[0005]

[Problems to be Solved by the Invention]

However, the method of ejecting pressurized gas into the water presents a problem in that energy is needed in operating the pressurizing equipment so that it results in a loss

of part of the energy savings achieved by reducing the frictional resistance. Especially, if the gas is ejected into the water from relatively deep locations below the surface such as at the bottom surface of large capacity vessels, it is necessary to pressurize the gas to a higher pressure relative to the water pressure (static pressure), thus resulting in expending a large amount of energy.

[0006]

This invention is provided in view of the above circumstances, and the objectives of the invention are as follows.

(1) To effectively reduce the energy consumption during cruising by lowering the frictional resistance at a lower energy consumption.

(2) To mix bubbles into the water efficiently to achieve effective reduction in frictional resistance.

[0007]

[Means for Solving the Problems]

In order to solve the above-mentioned problems, the invention according to claim 1 adopts, in a friction reducing ship for reducing the frictional resistance of a ship body by ejecting bubbles on the submerged surface of the ship body, a technique of providing a negative pressure forming section protruding from the submerged surface of the ship body for creating a negative pressure region in the water having a pressure lower than a pressure in a gaseous space, a discharge opening provided at the rear of the negative pressure forming section for ejecting bubbles toward the negative pressure region in the water, a fluid passage having one end open to the gaseous space and having the other end open to the water by way of the discharge opening for directing the gas into the water from the gaseous space, and a gas supply apparatus for supplying the gas into the negative

pressure region.

Furthermore, the invention according to claim 2 adopts, in a method that reduces the frictional resistance of a ship body by ejecting gas bubbles on a submerged surface of the ship body, a technique for creating in the water a negative pressure region having a pressure lower than a pressure in a gaseous space resulting from the ship body cruising through the water, directing a gas from the gaseous space to the negative pressure region in the water, ejecting bubbles into the water, and supplying the gas toward the negative pressure region by means of a specific apparatus.

[0008]

According to this invention, since a negative pressure region is formed in the water having a pressure lower than a pressure in a gaseous space by a negative pressure forming section, a gas is directed from the gaseous space into the water by a fluid passage. Furthermore, by supplying the gas into the fluid passage by a gas supply apparatus, the volume of gas flowing inside the fluid passage is increased, and a large volume of bubbles are ejected from a discharge opening.

[0009]

[Embodiments of the Invention]

Below, an embodiment will be described with reference to the figures, wherein the friction reducing ship according to this invention is applied to a bulk ship such as a tanker or freighter.

In Fig. 2, reference symbol M is a friction reducing ship, 10 is a ship body, 11 is a bubble generation apparatus, 12 is a ship body outer hull (submerged surface), 13 is a screw, 14 is a rudder, and 15 is the water surface (waterline).

[0010]

A VLCC (Very Large Crude Oil Carrier), for example, corresponds to the bulk ship as the friction reducing ship M. In comparison with other types of vessels, the surface area on the bottom of the ship is formed to be relatively large in comparison with the side of the ship in the ship body outer hull 12 (submerged surface) which is beneath the waterline 15. Moreover, the bubble generation apparatus 11 is disposed at the front of the ship body 10 (bow side).

[0011]

As shown in Fig. 2(b), the bubble generation apparatus 11 is constituted by a fluid guiding body 20 disposed at an opening 12a provided on the bottom of the ship, and an air induction pipe (AIP) 21 connected to this fluid guiding body 20.

[0012]

The fluid guiding body 20 is constructed overall as a component member of a pipe-shape (e.g., cylindrical shape) having a hollow internal section, and flanges 22, 23 for connecting to the air induction pipe 21 or to the ship body outer hull 12 are provided at both ends in the axial direction. Also, the end surface of the side connected to the ship body outer hull 12 (lower end) is formed at an angle with respect to the axial direction (an inclined surface 24). A discharge opening 25 constituting a through-hole is formed on the inclined surface 24 as a hollow opening inside the fluid guiding body 20. This discharge opening 25 (inclined surface 24) is arranged so as to face rearward (stern side). Moreover, the fluid guiding body 20 is disposed such that a portion of the inclined surface 24 projects from the submerged surface 12 of the ship body, and such that a portion of a side surface 26 is in a projected state perpendicular with respect to the submerged surface 12, as a negative pressure forming section.

[0013]

The air induction pipe 21 is constituted primarily of pipe shaped members, and is installed roughly through the ship body 10 and is connected to the fluid guiding body 20 via a flange 27. By connecting the air induction pipe 21 and the fluid guiding body 20, a fluid passage 30, serving as the internal space thereof, is formed. The fluid passage 30 is open at one end to a gaseous space (atmosphere) by way of an air intake opening 21a of the air induction pipe 21, while the other end opens into the water by way of the discharge opening 25. Here, the cross sectional area and shape of the fluid passage 30 (internal space of the fluid guiding body 20 and the air induction pipe 21) are set so that a desired amount of the fluid flows at a low pressure loss.

[0014]

Here, the shape and positioning of each component of the bubble generation apparatus 11 are designed by flow field analysis of CFD (Computational Fluid Dynamics) or the results of cruising experiments so as to obtain the desired shape of the flow of water at the rear of the fluid guiding body 20 during cruising.

[0015]

In other words, the protruding height of the side surface 26 of the fluid guiding body 20 from the submerged surface 12 of the ship body is set so that a negative pressure region having a pressure lower than that of the gaseous space (atmosphere) is formed in the water at the back side of the fluid guiding body 20 by the flow of water relative to the ship body 10, during cruising at a prescribed speed Vs.

[0016]

Also, the bubble generation apparatus 11 is provided with a gas supply apparatus 35 to supply gas at a given timing into the fluid passage 30. The gas supply apparatus 35 is used to charge air into the fluid guiding body 20 by way of a supply pipe 36 by altering

the operating state of the gas (air) admitted from the gaseous space such as a blower (fan) or pump. The timing for supplying air is determined by a control apparatus or an operator, not shown in the diagram, based on the results of measurements by a measurement apparatus 37 installed at the air intake opening 21a of the air induction pipe 21. In this case, when the flow rate of air into the air induction pipe 21 exceeds a given value, for example, the control apparatus commands the gas supply apparatus 35 to begin air supply. The measurement apparatus 37 used includes instruments capable of measuring a gas flow, such as a flow meter and flow velocity meter.

[0017]

Further, as the material of the fluid guiding body 20 and the air induction pipe 21, those which provide a surface which is corrosion resistant primarily with respect to sea water and which is resistant to attachment of marine organisms, such as metals which have undergone some corrosion resistant treatment, or resins, etc., are preferably used. Also, the bubble generation apparatus 11 may be provided such that one or more units are arranged according to the breadth of the bottom of the ship. Reference symbols 28, 29 shown in Fig. 2(b) represent packing for the connecting flanges.

[0018]

Next, a method of reducing the frictional resistance of a ship body by means of the friction reducing ship M constituted as described above will be explained with reference to Fig. 1.

In the stationary state of the ship, water (seawater) ingresses into the fluid passage 30 (the internal space of the fluid guiding body 20 and the air induction pipe 21 shown in Fig. 2) to about the same level as that surrounding the ship body 10. When the ship body 10 begins to cruise using the thrust of the screw 13 (refer to Fig. 2), a flow of water 40

relative to the ship body 10 is formed.

[0019]

In the cruising state, at the bottom of the ship, the fluid passage of water is narrowed by the side surface 26 of the fluid guiding body 20 so that the flow velocity of water flowing along the bottom of the ship increases, and the acute angle of the protruding end of the side surface 26 forms a separation layer in the water. Such actions lead to local lowering of the static water pressure at the back surface side of the side surface 26, i.e., in the water at the inclined surface 24 side.

[0020]

Then, when the cruising speed of the ship body 10 reaches a certain ship speed Vs (standard cruising speed, for example), a negative pressure region 41, having a lower pressure relative to the atmosphere, is formed in the water at the inclined surface 24 side.

[0021]

In this case, compared with the pressure at the air intake opening 21a, the pressure at the discharge opening 25 facing the negative pressure region 41 is low so that the fluid (seawater and air) inside the fluid passage 30 is subjected to a pressure gradient force such that the seawater is discharged from the fluid passage 30 and the air flowing in from the air intake opening 21a is ejected into the water by flowing through the fluid passage 30.

[0022]

Then, the gas ejected into the water becomes mixed in the water as air bubbles 42, and numerous bubbles 42 intervene in the vicinity of the submerged surface 12 of the ship body 10 leading to a reduction in the frictional resistance of the ship body 10.

[0023]

The energy required to eject the air into the water is primarily the energy for changing the position of the gas. This energy is obtained by varying the flow conditions of the water by means of the side surface 26 of the fluid guiding body protruding from the submerged surface 12 of the ship body, and is less than the energy consumed in compressing and ejecting the gas into the water. For this reason, the energy expended in cruising is effectively reduced by lowering the frictional resistance of the ship body 10.

[0024]

However, in this friction reducing ship M, when the ship is cruising at a certain ship speed Vs, the pressure gradient force created by the negative pressure region 41 reaches a roughly constant value so that the amount of bubbles 42 ejected into the water by the action of the pressure gradient force also becomes essentially constant.

[0025]

Therefore, in this embodiment, for the purpose of further reducing the energy consumption effectively during cruising, gas (air) is supplied at a given timing into the fluid passage 30 using the gas supply apparatus 35. That is, when the volume of flow of air into the air induction pipe 21 to be measured by the measurement apparatus 37 exceeds a given amount, a control apparatus or an operator (including remote operation), not shown in the figures, controls the gas supply apparatus 35 and air is supplied into the fluid passage 30. By so doing, the volume of air flowing in the fluid passage 30 is increased, and numerous bubbles 40 are ejected from the discharge opening 25. Therefore, the frictional resistance of the ship body 10 is further reduced.

[0026]

In this case, because the pressure inside the fluid passage 30 is negative relative to atmospheric pressure, the energy required to supply air into the fluid passage 30 is very

small. In other words, because the pressure gradient force also acts on the air inside the supply pipe 36 , it is only necessary to enhance the air motion by using the gas supply apparatus 35 to cause a large volume of air to flow through the fluid passage 30. Therefore, in this friction reducing ship M, in addition to the pressure gradient force generated by the negative pressure region 41, the flow of air inside the fluid passage 30 is assisted by the gas supply apparatus 35 making it possible to eject a large volume of bubbles 40 into the water at low energy consumption.

[0027]

Also, in this embodiment, the discharge opening 25 for ejecting gas into the water is provided on the inclined surface 24, which is disposed at an angle to the submerged surface 12 of the ship body. Therefore, compared with the case of disposing the discharge opening within a plane parallel to the submerged surface 12, the surface area of the opening of the discharge opening within a given region of the submerged surface 12 of the ship body is large, and is suitable for ejecting a large volume of bubbles.

[0028]

Further, in the formation of the negative pressure region 42, it is considered that the shape and Reynolds number of the negative pressure forming section (side surface 26 of the fluid guiding body) are the primary governing factors, and disadvantages arising from the water depth are less likely to occur, so that the technology of this invention can be favorably applied to bulk ships.

[0029]

Also, the shapes and combination of each component shown in this embodiment are just examples, and various modifications within the scope of this invention based on design requirements are possible. Furthermore, in the above embodiment, an example of

applying this invention to a bulk ship is given, but it is not limited to such an application, and it is applicable to other ships such as high-speed ships. Furthermore, the size, number and location of the bubble generation apparatus 11 are appropriately chosen according to the shape of the ship body. Furthermore, the cross sectional shape of the fluid guiding body 20 (or air induction pipe 21), such as a cylindrical tube or angular tube, is optionally set so as to reduce the resistance to a fluid flowing inside as much as possible.

[0030]

[Effects of the Invention]

As described above, according to this invention, by disposing a portion of a negative pressure forming section so as to project from a submerged surface of a ship body, use can be made of a pressure gradient force, gas can be ejected into the water at a low energy consumption, and it is possible to carry out reduction in frictional resistance of the ship body. Furthermore, by supplying a gas into a fluid guiding body by means of a gas supply apparatus, it is possible to increase the volume of gas flowing inside the fluid guiding body at a low energy, and it is possible to eject a large volume of bubbles from a discharge opening. Accordingly, it is possible to implement an effective reduction in frictional resistance by means of a large amount of bubbles and reduce the energy consumption during cruising.

[Brief Description of the Drawings]

[Figure 1] This is a conceptual drawing showing an example of a method for reducing the frictional resistance of a ship body using the friction reducing ship according to this invention.

[Figure 2] This is a structural diagram schematically showing one embodiment of applying the method of reducing frictional resistance of a ship body according to this

invention to a vessel.

[Brief Description of the Reference Symbols]

M friction reducing ship

10 ship body

11 bubble generation apparatus

12 ship body outer hull (submerged surface)

15 water surface (waterline)

20 fluid guiding body

21 air induction pipe

24 inclined surface

25 discharge opening

26 side surface (negative pressure forming section)

30 fluid passage

21a air intake opening

35 gas supply apparatus

37 measurement apparatus

40 flow of water

41 negative pressure region

42 bubbles

[Document Type] Abstract

[Abstract]

[Problem] To provide a friction reducing ship and a method for reducing frictional resistance of a ship body, in which it is possible to effectively reduce the energy consumption during cruising by carrying out reduction of frictional resistance at a low energy consumption.

[Means for Solving the Problem] A negative pressure region 41 is formed in the water having a pressure lower than that in a gaseous space resulting from a ship body 10 cruising through the water, a gas is directed to the negative pressure region 41 in the water from the gaseous space, bubbles 42 are ejected into the water, and the gas is supplied to the negative pressure region 41 by a specific apparatus.

[Elected Drawing] Figure 1

FIG. 1

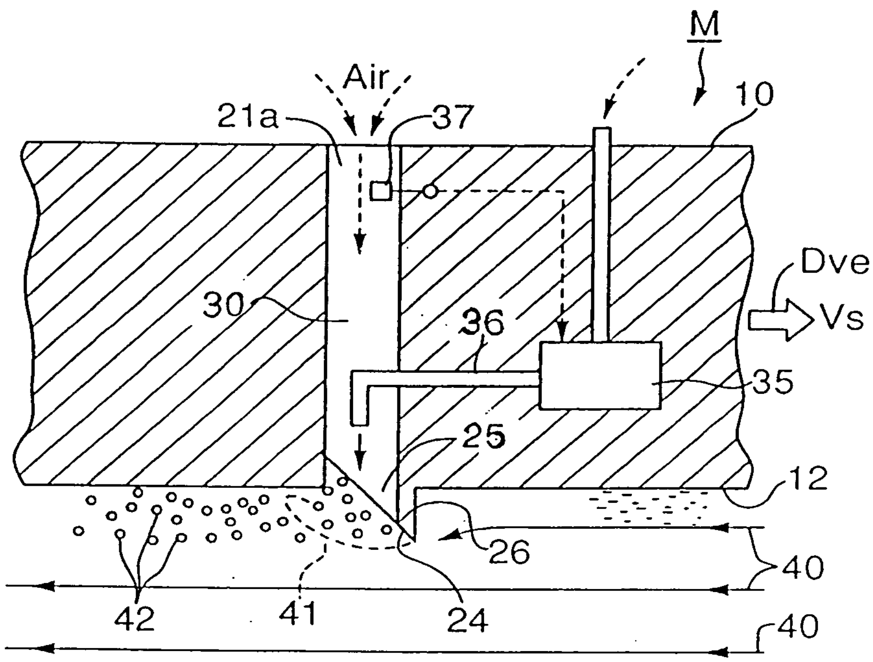
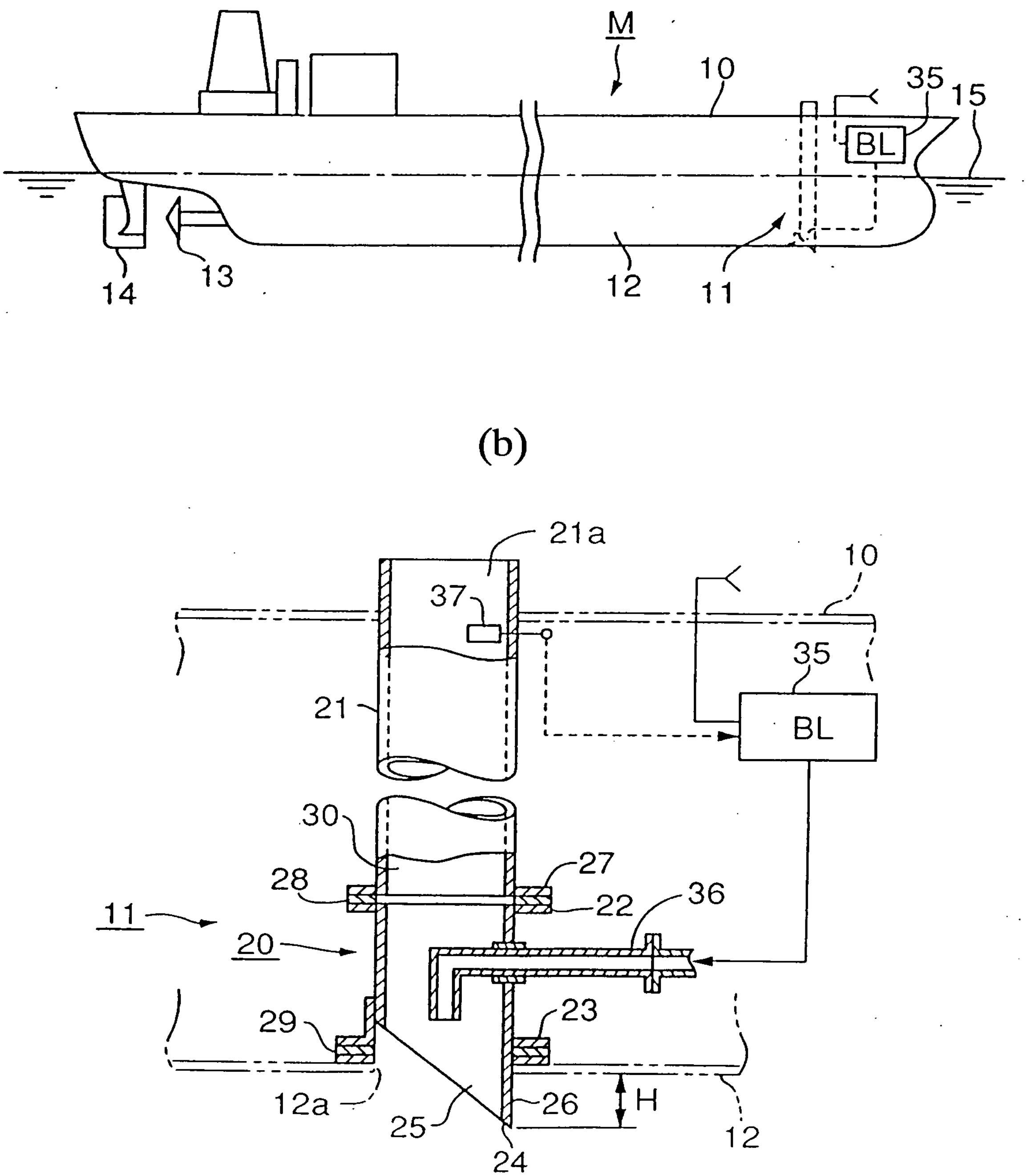


FIG. 2

(a)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